Design of gold nanoparticles for radiotherapy using Monte Carlo simulations of secondary X-rays and electrons

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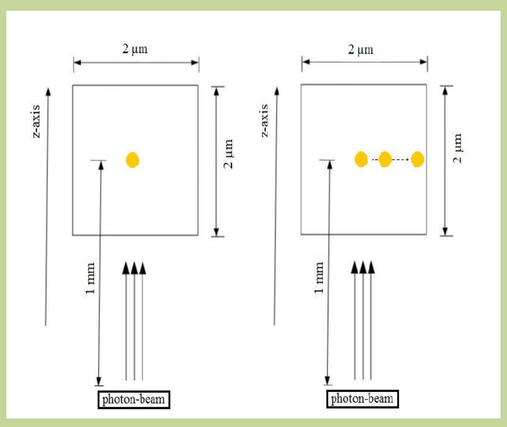
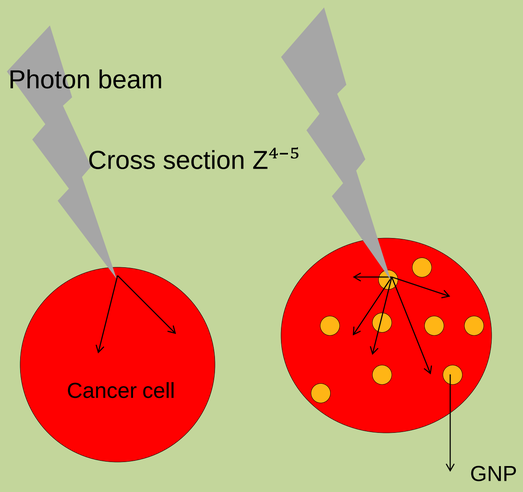
Due to the high Z-value of gold compared to normal soft tissue, X-rays interact more with gold then with soft tissue. This offers possibilities in cancer treatment. The addition of gold nanoparticles offers a way to enhance the effectiveness of radiation in low energy X-ray therapy. In order to obtain the maximal result, we need to understand how the energy is deposited in the area of the gold nanoparticles. Via Monte-Carlo simulations we tried to obtain a better understanding of the dose distribution.

Setup



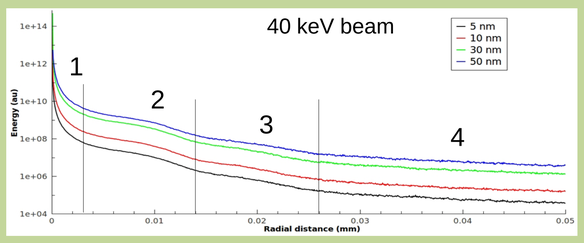


Geant4 was used to do the simulations (with PENELOPE library)

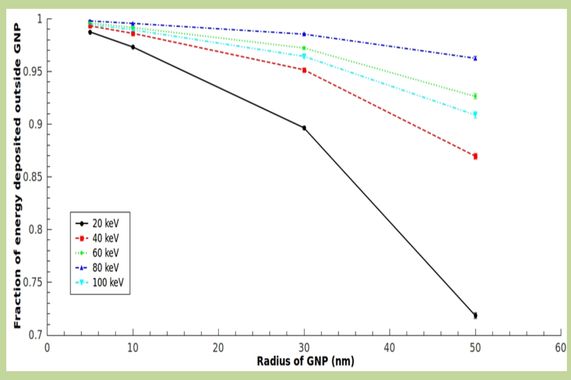
Radial energy distribution

4 areas:
- low energy electrons
- l-shell
- m-shell
- background

Background is proportional with r^3

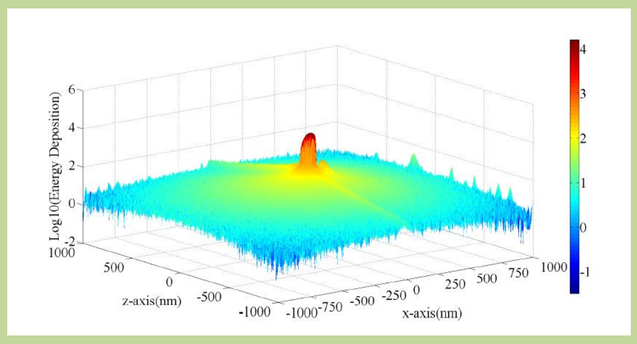


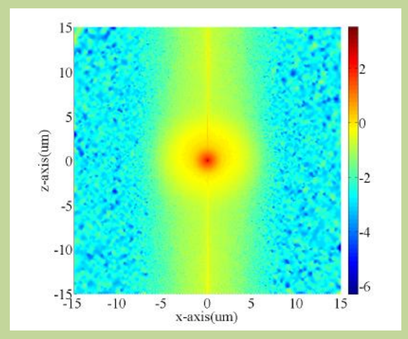
Self-absorption
Less self-absorption due to taking secondary X-rays into account.



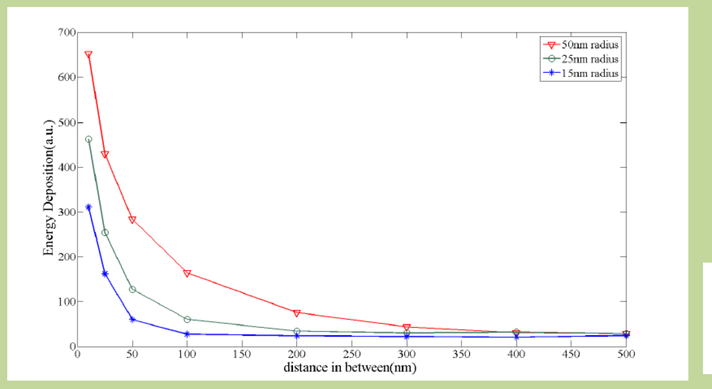
2D-energy distribution

To obtain more information on how gold nanoparticles will interact with X-rays, we used a 2D detector.





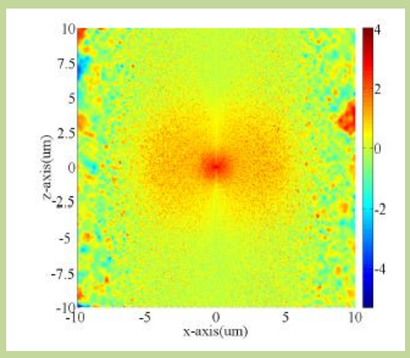
➡ Interaction vs distance



$$y = a * x^{-b} + c$$

constants	50 nm radius	25 nm radius	15 nm radius
a	$517 * 10^6$	$62,6 * 10^6$	$3.24 * 10^6$
b	2.90	2.90	2.52
c	29,19	28,06	18,44

➡ Interaction vs angle



Butterfly shape

Conclusions

This study demonstrates that energy deposited by a gold nanoparticle has a background value which scales with the volume of the gold nanoparticle, this amount is significant and this can also be seen in the self-absorption. From 2D-graph we learned that there is interaction between two gold nanoparticles which decreases with a power of 2.9.

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